Estimation of Electricity Demand Function for Algeria: Revisit of Time Series Analysis

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Abstract: This paper aims to empirically re-examine whether economic growth has effect on electricity consumption for Algerian economy. We have incorporated urbanisation and trade openness in electricity demand function as additional determinants of electrictyy consumption for the period of 1971-2012. For empirical purpose, we have applied the recently developed combined cointegration test proposed by Bayer and Hanck (2013) and bounds testing approach to cointegration by Pesaran et al. (2001) for establishing the cointegration between the variables by accomodating structural breaks.

The results expose that income growth leads to higher electricity demand along with urbanization being another major contributing factor of rising electricity demand. In contrast, trade openness leads to reduce electricity demand. The causal association between the variables is further exmained with the application of innovation accounting approach of Vector Autoregressive (VAR). The empirical evidnce inidactes the presence of the neutral effect between income growth and electricity use. Urbanization causes electricity use and electricity use causes urbaniation in Granger sense.

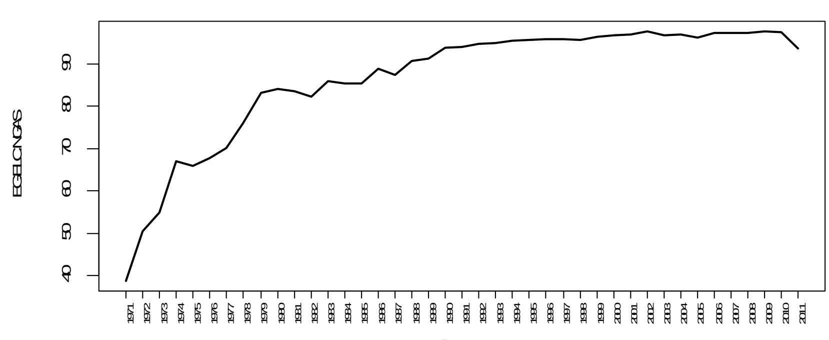
Keywords: Electricity, Growth, Urbanization, Trade Openness

1. Introduction

After the Second World War, there was a growing need for infrastructure and energy consumption by the major advanced economies. This was mainly aimed at fast restoration of the economies, through acceleration of industrial activities and along with a concomitant rapid technological advancements in the major advanced economies in an effort to further maintain the momentum of higher economic growth during a relatively peace world environment. This seems to have had a similar demonstrative effect for the developing economies. Towards these endeavors, this has subsequently led to an enduring rising demand for energy in most of developing economies since the second half of 20th century. Electricity infrastructure is believed to have greater potential in contributing to economic activity and to generate employment opportunities in developing economies compared to developed regions of the globe. This in turn has specifically led to huge increasing demand for electricity as a cleanest and efficient source of energy along with exploration of alternative efficient sources of renewable and nonrenewable energy sources across developing economies.

In Algeria, major electricity generation source is natural gas with a 92% of total production (Figure-1). In 2002, we recorded the highest level with 97.63%. Electricity from hydro power with an annual average of 3.97% has been recorded between 1971 and 2011[1] (Figure-2). Algeria has also been made efforts to generate power from solar and wind energy sources for its consumption and distribution to other European economies. Between 1992 and 2012, electricity use per capita in Algeria has jumped from 721.53 kWh per capita in 2001 to around 1406 kWh per capita in 2012 which corresponds to an annual average rate of around 6.25% (Hamiche et al. 2015). Algeria has developed a national program for the period 2010–2050 to promote concrete actions in renewable energy (Table-1). This program has an objective to achieve a share of renewable energy sources in electricity supply of 5% by 2017 and 10% by 2020. This country plans to export 6000MW solar energy electricity to Europe by 2020. Algeria has a high solar capacity with more than 3600h per year do sunshine (Hamiche et al. 2015). A scientific study conducted by the German Aerospace Center (2013) show that Algeria has a potential of 169 Terawatt-hours a year (13 Terawatt-hours a year) of solar thermal (photoelectric energy) representing 60 times of the current European countries energy demand.

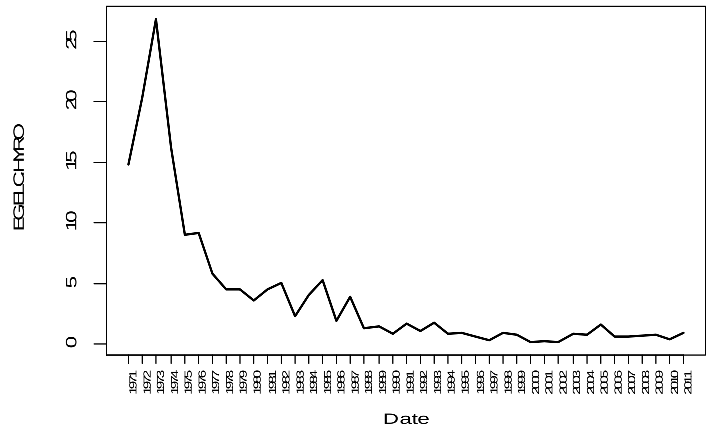
Figure-1: Electricity productionfrom natural gas sources(%of total production) in Algeria



[1]Before independence in 1962, almost 50% of Algeria's electricity production was generated by hydroelectric power; half a century later only 3.97 percent of capacity was hydroelectric.

Source: world Bank (2014)

Figure-2: Electricity productionfrom hydroelectric power(%of total production) in Algeria



Source: world Bank (2014)

Table-1: Investment in Renewable Energy Technologies (billion US$)

	2010-2020	2020 - 2030	2030-2040	2040 - 2050
Hydro	34.1	24.7	24.1	20.6
Wind	79.4	84	36.7	41.6
Photovoltaic	35.2	79.4	78.3	77.3
Thermal solar	11.3	43.6	49	49.7
Marine	2.8	2.7	3.1	2.7
Total	162.8	234.4	191.2	191.9

Source: Hamiche et al. (2015)

The case with Algeria is much different from other energy consuming nations as it relates to energy. This is one of the surplus energy economies as it produces and exports a major chunk of its produced oil and natural gas to European economies, after meeting its domestic demand. The hydrocarbons continued to represent the lion's share of Algerian exports with 95.75% of the total volume, i.e. $56.2 billion during 2014, against $57.23 billion in the past year. Similarly, it is also making efforts to produce more electricity from renewable sources and exports to European economies by laying the pipelines through sea routes. However, for Aglerian government, exploration of renewable energy sources is important due to its geographical and locational advantages, but it requires time and resources for their effective explorations. The current electricity generation from renewable sources is very low i.e. 0.006% of the total electricity generation. The Mediterranean Renewable Energy Program (MEDPRO) has an objective of producing almost 40% of domestic electricity consumption from sources of renewable energy till 2030 (Bélaïd and Abderahmani, 2013). The summary statistics reported in Table-1 indicate that 2,000 MW, 2,800 MW and 7,200 MW electricity will be generated from wind, solar PV and solar thermal respectively.

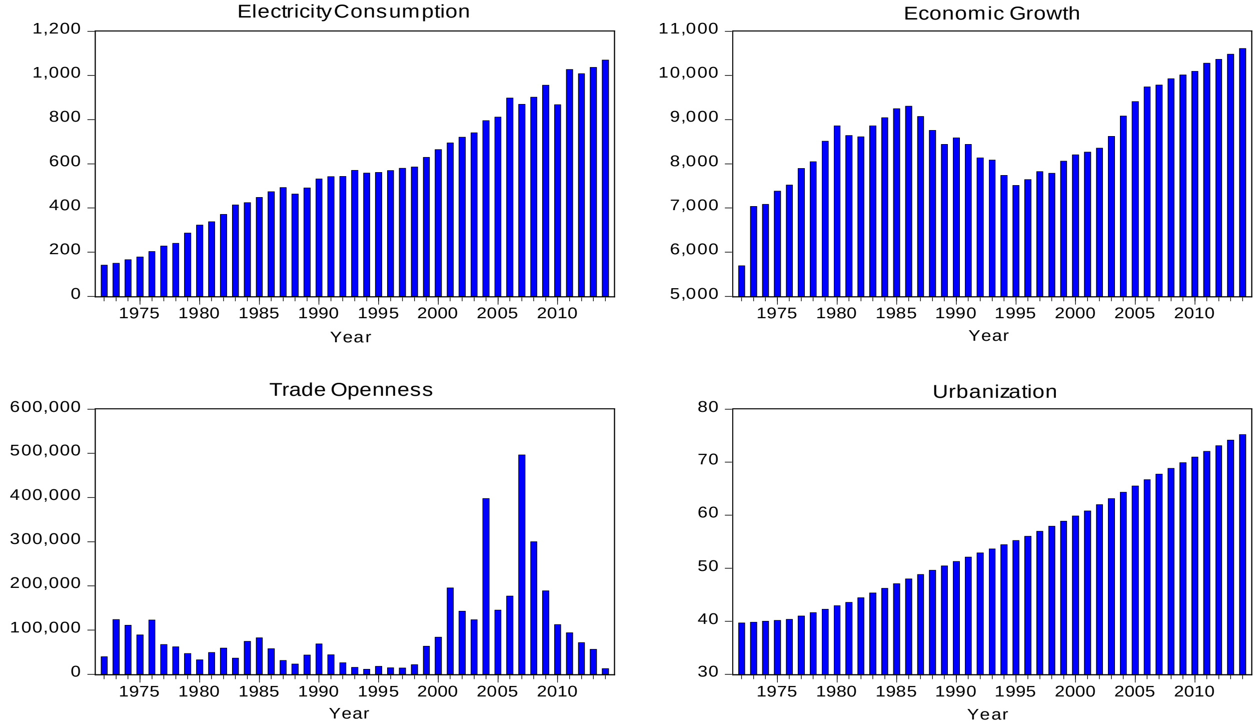
Table-2: MEDPRO Energy Reference Scenario for Renewable Energy

	Electricity Generation				Average Annual Growth		
	1970	2009	2020	2030	1970-2009	2009-2020	2020-2030
Electricity Output – TWh	2	43	71	113	7.7%	6.2%	4.7%
Hydro	0	0.3	0.3	0.3	1.1%	1.9%	-0.7%
Renewable	0	0.01	12	30		93.9%	47.9%
Wind	0		1	4			
Solar PV	0	0.01	3	7		69.4%	37.9%
Solar Thermal	0		8	19			
Installed Capacity – MW	0	11325	19082	30975		7.7%	4.9%
Hydro		228	394	418		4.1%	2.9%
Renewable	0	28	4821	12002		96.9%	33.5%
Wind		0.08	520	2000			62.2%
Solar PV		3	1100	2800		72.1%	38.9%
Solar Thermal		25	3200	7200			31%

Source: the MEDPRO Energy Reference Scenario (2012)

Due to its geographical location, Algeria is considered to posses one of the highest solar potentials in the world (Table-1). A 1/20 of Saharan surface is covered with solar panels which can be utilized to supply electricity for the entire planet (Bélaïd and Abderahmani, 2013). Although, it is an energy surplus economy as reflected from its increasing exports of different sources of energy but at the same time, it also consumes a greater proportion of different forms of energy comparing its exports. Given that electricity generation has the high potential external demand from European economies, either it has to produce more of it to be able to export more or significantly reduce its own consumption of it. But less consumption of this source of energy comes at a cost of its consumption is resulting in higher economic growth. Therefore, the future energy policy of Algeria can be comprehensively carved only by empirically establishing the linkages between electricity use and inocme growth or electricity production or distribution (exports) and economic growth (Figure-3). In such situation, reduction in domestic consumption of electricity results in drastic reduction in economic growth of Algerian economy than the gains from electricity exports, national electricity energy policy has to maintain the balance between its consumption and distribution. Given this context, it is a useful empirical exercise to understand and analyze the relationship between electricity use and income growth, trade and urbanization for the Algeria to have a comprehensive national electricity energy policy. The trends of electricity use, income growth, trade and urbanization is shown in Figure-3.

Figure-3: Trends in Electricity, Growth, Trade and Urbanization in Algeria



Given this background, this present paper attempts to reinvestigate the relationship between economic growth and electricity consumption for Algeria by incorporating urbanisation and trade openness in electricity demand function which has not been attempted in existing literature. This study uses annual frequency data covering 1971-2012 time period. In the presenc of structural breaks, we apply bounds testing approach for examining the cointegration between eectricty demand and its determinnats. The direction of causality between the variables is investigated by applying innovation accounting approach. This type of exercise is hardly attempted for Algeria. The empirical evidence exposes that income growth leads electricity demand but openness of trade declines it. Urbanization is a major contributing factor to electricity consumption. The causality results show that the relationship between urbanization and electricity use is bidirectional. Neither income growth causes electricity use nor electricity use causes income growth. Trade openness and urbanization cause economic growth. We find evidence of the neutral effect between trade openness and electricity consumption.

II. Literature Review

Identifying the significance of electricity in the process of economic development has remained the top most agenda of different nations of the world. There are pioneering works in the literature. Table-3 presents an overview of comprehensive studies on the association between electricity use, economic growth, urbanization and trade. For instance, Kraft and Kraft (1978) in their classic work for USA showed that income growth causes use of electricity during 1947 to 1974. Following this, there has been a great deal of empirical researches on the relationship between electricity use and income growth but the direction of the causality between the variables is not obvious as often the results are mixed. For example, Ahamad and Islam, (2011) for Bangladesh found the short-run causality runns from electricity use to GDP growth but in the long-run, the feedback effect is found between the variablesfor the period of 1971-2008[2].

Table-3: Summary of Selected Studies on Electricity-Growth Nexus

No.	Feedback Effect	Growth Hypothesis	Conservation Hypothesis	Neutrality Effect
1.	Mallick, (2009) for India	Kraft and Kraft (1978) for USA	Mozumder and Marathe (2007) for Bangladesh	Fateh and Abderrahmani, (2013) for Algeria
2.	Ouedraogo (2010) for Burkina Faso	Aqeel and Butt, (2001) for Pakistan	Ghosh, (2002, 2010)	Acaravci and Ozturk (2010) for Transition countries
3.	Ouedraogo (2010) for Burkina Faso	Shiu and Lam (2004) for China	Ahmad and Jamil, (2010) for Pakistan	
4.	Abbas and Choudhury, (2013) for India	Yuan et al. (2007) for China	Chandran et al. (2010) for Malaysia	
5.	Solarin and Shahbaz, (2013) for Angola	Akinlo, (2009) for Nigeria		
6.	Bélaïd and Abderahmani (2013) for Algeria	Alam and Sarker (2010) for Bangladesh		
7.	Marques et al. (2014) for Greece	Ahamad and Islam, (2011) for Bangladesh		
8.	Iyke and Odhiambo, (2014) for Ghana	Buysse et al. (2012) for Bangladesh		
9.	Dogan, (2015) for Turkey	Iyke (2015) for Nigeria		
10.	Lin and Liu (2016) for China			
11.	Rafindadi and Ozturk (2016) for Japan			
12.	Cerdeira and Moutinho (2016) for Italy			

Stern (1993) and Tang (2008) observing electricity use plays vital role in domestic production, found that domestic production is cause of electricity consumption. Horn, (1999) observed that electricity consumption per capita nearly corresponds to the low average income of Ukraine. Aqeel and Butt, (2001) investigated the causal relationship between energy consumption and economic growth for Pakistan. By applying cointegration and Hsiao's version of Granger causality, they evidenced that electricity consumption leads to economic growth but similar is not true from opposite side. Using the annual data for 1960-2008, Ahmad and Jamil, (2010) found that economic activity causes electricity consumption in Granger sense. Lean and Shahbaz, (2012) validated the direct but positive impact of electricity consumption on economic growth for Pakistan. Shahbaz et al. (2012) also observed that electricity consumption and economic growth are complementary for each other i.e. feedback effect for Romania during the period 1980-2011.

Lin (2003), found the direction of relationship running from economic growth to electricity consumption for China during 1978–2001. In contrast, Shiu and Lam (2004) observed the direction of causal association running from electricity consumption to economic growth over

[2] For Bangladesh economy, Buysse et al. (2012) reported the presence of feedback effect between electricity consumption and eoncomic growth in long-run but inshort-run, *energy-conservation hypothesis* is valid. Alam and Sarker (2010) also confirmed that in short-run, electricity generation causes economic growth.
In contrast, Mozumder and Marathe (2007) concluded that a reverse causation which runs from economic growth to electricity consumption demand for Bangladesh during 1971 to 1999.

the period of 1971-2000 and later, Yuan et al. (2007) confirmed the findings of Shiu and Lam (2004). Ghosh (2009) further claimed that electricity consumption is cause of economic growth. Mallick, (2009) found the feedback relationship between growth in electricity consumption and economic growth for India during 1970-2005[3]. Saeki and Hossain, (2011) found existence of conservation hypothesis for India, Nepal and Pakistan, but growth hypothesis is confirmed in Bangladesh. In a comparative study on Pakistan and India, Abbas and Choudhury, (2013) probed the association between electricity consumption and economic growth at sectoral level covering the period 1972-2008. They noted that agriculture electricity demand agriculture causes economic growth and similar is ture from opposite side in India but in Pakistan, *agriculture growth hypothesis* is valid. The feedback effect also exists between electricity use and eocomic growth in Pakistan

Akinlo (2009)'s causality result for Nigeria exhibited that real GDP growth is cause of electricity usage growth during 1980 to 2006. Ouedraogo (2010) determined the empirical association between electricity demand and eoncomic growth in Burkina Faso covering 1968-2003 time period. The empirical results show the significant role of electricity consumption in determining economic growth. Chandran et al. (2010) re-investigated the relationship for Malaysia discovered that economic growth is positively caused by electricity consumption. In the case of Angola, Solarin and Shahbaz (2013) added urbanization in electricity demand function and found the presence of feedback effect between electricity consumption and economic growth as well as between urbanization and electricity consumption. Fateh and Abderrahmani, (2013) addressed the issue of electricity consumption along with consumption of other energy sources, on economic growth in Algeria by applying Zivot–Andrews unit root test, Gregory–Hansen cointegration test and Vector Error Correction Models. Their results show that electricity sonumption does not contribute to eoncomic growth and vaiadtes the presence of neutral hypothesis for the both variables. Marques et al. (2014) examined the association between renewable electricity generation and economic activity in case Greece and found neutral effect between the variables. Al-mulali et al. (2014) probed the linkages between electricity consumption and economic growth for Latin American countries. They noted that renewable electricity consumption is more beneficial in stimulating economic activity. Iyke and Odhiambo, (2014) included inflation in production function to investigate association electricity consumption with economic growth. The found that electricity consumption is Granger caused by economic growth and inflation.

Karanfil and Li (2015) employed data of 160 countries for exploring the linkage between electricity use and economic growth. Their empirical exercise indicates the feedback effect between both variables in OECD and high income countries while conservation hypothesis is validated in South Asia and Pacific as well as MENA regions. Solarin and Ozturk, (2015) probed the affiliation between hydroelectricity consumption and economic growth for Latin America. They found that hydroelectricity positively impacts economic growth and growth-hypothesis is valid for Chile, Colombia, Ecuador and Peru. For Nigerian economy, Iyke (2015) applied the

[3] Ozturk, (2010) inidacted that application of various econometric approaches for determining the direction of causality between electricity consumption and economic growth may be cause of ambegious empirical evidence between the variables. The exclusion of relevant and potential variables also causes the validity of causal relationship between electricity (energy) consumption and economic growth.

trivariate VECM framework to scrutinize the rapport between electricity use and inocme growth. The empirical results confirm the presence of growth hypothesis. For Turkish economy, Dogan, (2015) noted that nonrenewable electricity consumption is positively linked with economic growth but renewable electricity consumption declines it. Furuoka, (2015) explored the association between the variables of interest using data of South Asia. The results showed the presence of cointegration and electricity consumption is cause of economic growth. Acaravci et al. (2015) probed the production function for determining the relationship between electricity consumption and economic growth in the presence of trade and foreign direct investment by applying the bounds testing approach. They reported that electricity consumption and foiregn direct investment add in economic growth but trade lowers it but economic growth is Granger caused by electricity consumption. Fakih and Marrouch, (2015) employed augmented production function by accomodating employment as additional determinant for Labonan economy. They noted that electricity consumption impedes economic growth but employment boosts economic acticity but the feedback effect is confirmed between electricity consumption and eonocmic growth. For Turkish economy, Acaravci et al. (2015) probed the electricity-growth nexus by applying bounds testing and VECM Grager causality approaches and reported that electricity consumption (trade openness) adds (declines) economic growth. Abdoli et a. (2015) scrutinized the linkages between electricity consumption and economic growth for OPEC countries and reported the presence of feedback effect between both variables. Furthermore, their empirical analysis indicated the importance of exploring new sources of energy to maintain the rsing demand of electricity in the region.

Recently, Marques et al. (2016a) investigated the association between electricity use and industrial production for Greek economy for ther period of 2004-2014 using month frequency data. They found that electricity generation from fossil sources play main role in promoting industrialization and hence economic growth. Marques et al. (2016b) exmained the relationship between elecrticty gereation mix and economic growth for French economy by applying the bounds testing approach to cointegration. Their empirical analysis reported that the variables are found to be cointegrated. Furthermore, electricity generation from nuclear energy is positively linked to economic growth with less CO_2 emissions. On contrary, electricity from renewable energy sources impedes economic activity and hence declines domestic production which in resulting, lowers eocomic growth. For Chinese economy, Lin et al. (2016) investigated the effect of renewable electricity consumption factors affect electricity demand. Their results indicated that economic growth stimulated renewable electricity consumption but tarde openness, forign doirect investment, financial development and fossil fuel energy consumption lower the demand for electricity consumption. Bento and Moutinho (2016) employed bivariate framework to determine the relationship between electricity consumption (hydro sources) and economic growth in the largest consumers of hydroelectricity. Their empirical evidence indicates the presence of bidirectional causality between hydroelectriccty consumption and economic growth. For GCC countries, Osman et al. (2016) invetsiagted the association between electricity consumption and economic growth and found that electricity consumption plays vital role in stimulating economic activity and hence economic growth. Their analysis also indiacted that elctricty consumption and economic growth are completmentary. Bashier (2016) applied the VECM Granger casuality and found the presence of feedback effect for electricity use and income growth. For Indian economy, Kumari and Sharma (2016) validated the presence of conservation-hypotheiss. Gokten and Karatepe (2016) incorporated current account deficit in electricity consumption function and reported that economic growth is stimulated and caused by electricity consumption[4]. Raza et al. (2016) noticed that electricity consumption contributes to economic growth. They also validated the presence of growth-hypothesis.

The main issue that we address here is the electricity consumption-economic growth nexus. In this regards, recent studies by Acaravi and Ozturk (2010), Apergis and Payne (2011), Cerdeira Bento and Moutinho (2016), Rafindadi and Ozturk (2016), Shahba et al. (2015), Lin and Liu (2016) and Payne (2010) found the interrelationship between both variables. However, the causal results pertaining a mixed results between electricity consumption and economic growth worldwide. Some recent studies have validetd the presence of growth-hypotheiss and some even have bidirectional causality between electricity consumption and economic growth. Apergis and Payne (2010) argued that because of the vital factor in the growth prospects mainly in developing countries which facilitating scientific and technological advancements mainly with ICT development and trade across the countries. This results in line with recent studies by Rafindadi and Ozturk (2016) and Lin and Liu (2016. The major distinguishing variables indicate that electricity consumption found to have a causal relationship with economic growth as well trade openness. Even, the deviation between electricity consumption and economic growth during the post and crisis period has also reflected with the electricity consumption patterns in Japan and China. While, Cerdeira Bento and Moutinho (2016) indicated that electricity consumption can be a suitable solution, reducing carbon emissions and played an important role for economic growth over time. Typically, Acaravci and Ozturk (2010) have argued about the electricity consumption-growth nexus for 15 transition countries. They noted that electricity consumption and eoncomic growth have no cointegration and neutrality hypotheiss is validated.

In the case of Algeria, Bélaïd and Abderahmani (2013) examined electricity-growth nexus by accommodating oil prices as additional determinant in production function by employing Gregory-Hansen cointegration and VECM Granger causality approaches for 1971-2010 time period. Their empirical results indicate the validation of feedback efefct. Moreover, the neutral effect is noted between oil prices and electricity consumption. However, Gregory-Hansen test may suffer from loss of power when the Data Generating Process is subject to multiple structural breaks. Given that there are numerous studies in existing literature which have interlinked electricity consumption demand with urbanization, trade openness and economic growth as important determinants for various other economies, in a similar spirit, the study specifies the electricity demand as a function of economic growth, urbanization and trade openness and explores on the empirical relationships between them for Algerian economy by employing more suitable advanced econometric techniques to verify the robustness of results obtained in previous studies. Since the literature in linking these variables is weak for a poor African economy like Algeria, this provides sufficient motivation to estimate an electricity consumption demand model suitable for Algeria, for drawing up for an efficient energy policy. The continued economic growth and urbanization has often been raising the prices of fossil fuels in Algeria in-spite of the fact that this is an oil producing economy. It appears that this development could mainly be due to the simultaneous economic growth that Algeria has been experiencing along the way. The consumption of electricity in Algeria has steadily been increased in past few years. Its share in consumption is almost closer to 30% following the share of oil products (41%) and the share of natural gas (25%) follows the share of electricity in consumption.

[4] Gokten and Karatepe (2016) reported that import-based energy causes current account deficit.

2. Data Sources and Variable Description

This paper re-exmaines the affiliation between electricity consumption and economic growth by integrating urbanization and trade in electricity demand function. Thus, increasing demand for electricity is mainly caused by increase in urban population, establishment of industrial, commercial, construction and household sectors (Lin and Liu, 2016). The rapid growth of urbanization and trade openness in developing countries has attracted much attention on ICT development, trade, industrial activities, urban cities development and financial activities. Moreover, many countries also increase mass transit services and public transportations based on electronically functional (Wang et al. 2015). These capacities has encouraged not only domestic economic activities, but has also increased imports and exports volumes (Srinivasan 2013, Cerdeira Bento and Moutinho 2016). The annual frequency data covering the period of 1972-2012 is employed. The data on electricity consumption, real GDP, urbanization and real trade has been collected from World Development Indicators (WDI) available on CD-ROM(2014)[5]. The functional form of electricity demand function is given as following:

$$E_t = f(Y_t, U_t, O_t) \tag{1}$$

All the series have been converted into per capita units by using population series. Further, we have transformed all the variables into logarithmic form for reliable and efficient empirical results. The estimable equation is modeled as following:

$$\ln E_t = \beta_1 + \beta_2 \ln Y_t + \beta_3 \ln U_t + \beta_4 \ln O_t + \mu_t \tag{2}$$

where β_1 is the constant term and β_i (for i = 2,3,4) are the long-run elasticities of electricity demand with respect to real GDP, urbanization and trade openness, respectively. The equation 2 is used in order to investigate the long-run relationship between $\ln E_t$ (natural log of electricity consumption (Kwt) per capita), $\ln Y_t$ (natural log of real GDP per capita), $\ln U_t$ (natural log of urbanization which equal to urban population/total population), $\ln O_t$ (natural log of trade openness which equal to real exports plus real imports/total population) per capita and μ_i is error assuming normally distributed.

3. Econometric Methodology

3.1. Bayer-Hanck Cointegration Approach

The time series seems to be cointegrated if two or more different series have intgetration containing lower integrating order in some linear combination among them. To exmiane cointegtaion between the variables, Engle and Granger (1987) developed a cointegration approach requiring that the variables should be integrated at I(1). This cointegration test efficiently works as we have small sample data but it is not free from criticisim due to its lower explanatory power properties. Johansen (1988, 1991) originated a new ointgeration test termed as *Johansen maximum eigenvalue* test. Although, *Johansen maximum eigenvalue* test performs better than Engle–Granger test but it requires that the variables to be considered in empirical model should be integrated at I(1). Latter on, Phillips and Ouliaris (1990) developed a *Phillips–Ouliaris cointegration* test in order to examine cointehration between the variables is a residual

[5] We have used total population to transform annual data from real terms into per capital units.

based cointegration test. There are some other cointegration tests available for examining cointegration between the variables such as Error Correction Model (ECM) based F-test of Peter Boswijk (1994), and Banerjee et al. (1998) also developed a ECM based *t*-test. It is noted that various cointegration tests provide ambegious empirical evidence due to different methodological backgrounds. To solve this issue, Bayer and Hanck (2013) developed a combined cointegration test based on Engle and Granger, Johansen, Peter Boswijk, and Banerjee tests. The combined cointegration test allows to unite different coingtegration tests for conclusive empirical findings. We apply combined cointegration test to examine either cointegration exists or not between electricity consumption and its determinants for Alerian economy. The Bayer and Hanck (2013) combined cointegration test follows Fisher (1932) formulae for combining the p-values of various individual tests:

$$EG-JOH=-2[\ln(P_{EG})+\ln(P_{JOH})] \tag{3}$$

$$EG-JOH-BO-BDM=-2[\ln(P_{EG})+\ln(P_{JOH})+\ln(P_{BO})+\ln(P_{BDM})] \tag{4}$$

The probability-values of Engel-Granger (EG), Johansen (JOH), Boswijk (BO), and Baneerjee-Doladoe-Mestre (BDM) cointegration tests is shown by P_{EG}, P_{JOH}, P_{BO} and P_{BDM} respectively. We may accept hyothpesis of cointgeration between the variables if calculated Fisher's statistic exceeds the critical value originated by Bayer and Hanck (2013).

3.2 The ARDL Bounds Testing Approach

This study emloys the bounds testing approach for examing cointegration between 'electricity use, trade, urbanization and economic growth' originated by Pesaran et al. (2001) by accommodating structural breaks. The bounds testing to cointegration is superior to traditional cointegration approaches. This test is appropriate if variables are found stationary at level or first diference even variables have mixed order of integration. The bounds testing approach produces proficient results for small sample. A simple linear transformation can be used to the dynamic unrestricted error correction model (UECM) from the bounds testing approach. The bounds testing approach incorporates short-run dynamics with long-run equilibrium path without influencing the long-run information. The UECM is modelled as follows:

$$\begin{aligned}\Delta\ln E_t &= \alpha_1+\alpha_T T+\alpha_E\ln E_{t-1}+\alpha_Y\ln Y_{t-1}+\alpha_U\ln U_{t-1}+\alpha_O\ln O_{t-1}+\sum_{h=1}^{O}\alpha_i\Delta\ln E_{t-h}\\ &+\sum_{i=1}^{p}\alpha_i\Delta\ln E_{t-i}+\sum_{j=0}^{q}\alpha_j\Delta\ln Y_{t-j}+\sum_{k=0}^{r}\alpha_k\Delta\ln U_{t-k}+\sum_{l=0}^{s}\alpha_l\Delta\ln O_{t-l}+\alpha_D D_1+\mu_t\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta\ln Y_t &= \alpha_1+\alpha_T T+\alpha_E\ln E_{t-1}+\alpha_Y\ln Y_{t-1}+\alpha_U\ln U_{t-1}+\alpha_O\ln O_{t-1}+\sum_{h=1}^{O}\alpha_i\Delta\ln Y_{t-h}\\ &+\sum_{i=0}^{p}\alpha_i\Delta\ln E_{t-i}+\sum_{j=0}^{q}\alpha_j\Delta\ln U_{t-j}+\sum_{k=0}^{r}\alpha_k\Delta\ln O_{t-k}+\alpha_D D_2+\mu_t\end{aligned} \tag{5}$$

$$\Delta \ln U_t = \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_U \ln U_{t-1} + \alpha_O \ln O_{t-1} + \sum_{h=1}^{O} \alpha_i \Delta \ln U_{t-h}$$
$$+ \sum_{i=0}^{p} \alpha_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta \ln O_{t-k} + \alpha_D D_3 + \mu_t \tag{6}$$

$$\Delta \ln O_t = \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_U \ln U_{t-1} + \alpha_O \ln O_{t-1} + \sum_{h=1}^{O} \alpha_i \Delta \ln O_{t-h}$$
$$+ \sum_{i=0}^{p} \alpha_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta \ln U_{t-k} + \alpha_D D_4 + \mu_t \tag{7}$$

The diference operator is shown by Δ while D is for dummy capturing structural break in the series. The residual term is indiacted by μ_t which is supposed to be having normal distribution. The selection of appropriate lag order for calculating ARDL F-statistic. The Akaike information criteria (AIC) is used due to its superior explanatory power. The reason for chosing appropriate lag order is that ARDL F-test produces different empirical results at different lag orders. We apply ARDL F-test suggested by Pesaran et al. (2001) for the computation of F-statistic to compare with critical bounds. The hypothesis of no cointegtaion between electricity consupion, economic growth, urbanization and trade opennenss is $H_0: \alpha_E = \alpha_Y = \alpha_U = \alpha_O = 0$ against $H_a: \alpha_E \neq \alpha_Y \neq \alpha_U \neq \alpha_O \neq 0$ is alternative hypothesis i.e. cointegration exists. The next is compare our calculated ARDL-F statistic with critical bounds generated by Pesaran et al. (2001) and Narayan (2005) for small samples. If regressors are stationary at I(0) we use lower bounds otherwise upper critical bounds are used for comparison with ARDL F-statistic. The cointegration exists if computed ARDL F-statistic is more than upper bound. If computed ARDL F-statistic is less than lower bound, we may conclude in favor of no cointegration. The decision for cointegration is uncertain if computed ARDL F-statistic is between upper and lower critical bounds. In order to examine the robustness of the ARDL estimates, we have applied diagonestic tests.

3.3 Innovative Accounting Technique

The Granger causality test does not provide statistics of the relative strength of causal relationships between variables beyond the chosen time period (Shan, 2005), nor it determines the extent feedback relationship between variables. To overcome this issue, this study utilizes the applications of Innovative Accounting Approach (IAA) to examine a causal relationship between a pair of electricity consumption, urbanization, traded openness and economic growth. The IAA draws on the Impulse Response Function (IRF) and forecast error variance decomposition to determine the extent of feedback between variables. The variance decomposition determines the proportion and extent of variation caused by a variable own shock and shocks caused in other variables (Enders, 1995). The influence of one standard deviation shock to the variable on other variables as well as future value of the variable sustaining the shock is examined using a system of equation (Shah, 2005). For example, if a shock stemming in economic growth significantly influences electricity consumptions and shock stemming in the latter have minimum influence on the former, we can conclude evidence that economic growth causes electricity consumption. If shocks stemming in variables significantly influences each other, that may conclude evidence of bidirectional causal relationship while if shock to a series accounts no impact, we can infer no causality between variables.

On the other hands, IRF assists us to determine the impact shocks on variables in a VAR framework though a time path. Through IRF, one may determines the “a variable” response to its own shocks and shock in another variable. For instance, electricity consumption is caused of economic growth if there is indication of significant response of electricity consumption to impulse of economic growth and vice versa. A VAR system takes the following form:

$$V_t = \sum_{i=1}^{k} \delta_i V_{t-1} + \eta_t \qquad \text{where, } V_t = (E_t, Y_t, U_t, O_t)$$

$$\eta_t = (\eta_E, \eta_Y, \eta_U, \eta_O)$$

$\delta_1 - \delta_k$ are four by four matrices of coefficients, and η is a vector of error terms.

4. Results and Discussions

Table-4 shows the descriptive statistics of all the variables incorporated in electricity demand function for Algerian economy. We note that economic growth is less volatile compared to urbanization and electricity consumption but trade openness has high volatility. The results of Jarque-Bera test (Table-4) point out that electricity consumption, urbanisation and trade openness are normally distributed. However, the same statistics also accept the null hypothesis of normal distribution for real GDP. The correlation analysis reports that correlation between economic growth and electricity consumption is positive. Urbanization positively correlated with electricity use. Trade openness and electricity consumption are negatively correlated. Income growth is positively correlated with urbanization and trade. The positively correlation exists between trade and urbanization.

Table-4: Descriptive and Correlation Analysis

Variable	$\ln E_t$	$\ln Y_t$	$\ln U_t$	$\ln O_t$
Mean	6.1973	9.0501	3.9746	11.1286
Median	6.3093	9.0535	3.9751	11.0870
Maximum	6.9432	9.2573	4.3061	14.1696
Minimum	4.9455	8.6464	3.6804	9.3034
Std. Dev.	0.5523	0.1224	0.1989	1.0141
Skewness	-0.7414	-0.6313	0.0475	0.5806
Kurtosis	2.6951	4.2233	1.7463	3.6777
Jarque-Bera	4.0104	5.4090	2.7663	3.1637
Probability	0.1346	0.0669	0.2507	0.2055
$\ln E_t$	1.0000			
$\ln Y_t$	0.7512	1.0000		
$\ln U_t$	0.9503	0.6583	1.0000	
$\ln O_t$	-0.2106	0.3270	0.3161	1.0000

There are number of tests available for examining stationary properties of the variables. But the conventional unit root tests offer spurious empirical evidence while testing unit root properties of the variables. This issue is handled by applying the structural break unit root test of Clemente-Montanes-Reyes (CMR) (1998). This test is superior to traditional unit root tests. This test has information about single as well as double unknown structural breaks. This test by Clemente-Montanes-Reyes (1998) is lead by an additive outliers (AO) model for capturing mean sudden changes while innovational outliers (IO) model captures the mean gradual changes. The AO model is suitable for series having sudden structural deviations compared to the gradual changes. The results reported by CMR unit root test are detaied in Table-5. The empirical evidence by CMR unit root test shows that electricity consumption has no unit root problem but economic growth, urbanization and trade openness are found non-stationary at their levels while structural breaks in the series are present. Algerian government implemented economic reforms for Paris Club Rescheduling in 1996 that affected economic growth rate and in resulting, it affected electricity demand in 1997. This reveals the mixed order of integrating of the variables. The CMR test with double structural breaks also provides different findings. We note that the variables are integrated at first difference i.e. I(1). In such situation, the ARDL bounds testing is appropriate for examining long-run relationship between the variables.

Table-5: CMR Detrended Structural Break Unit Root Test

Model: Trend Break Model								
	Level data				First difference data			
Series	T_{B1}	T_{B2}	Test statistics	K	T_{B1}	T_{B2}	Test statistics	K
$\ln E_t$	1997	---	-5.088**	6	1981	----	-9.908*	6
	1976	1997	-3.383	4	1986	1981	-10.475*	6
$\ln Y_t$	2000	---	-3.746	6	1992	----	-8.976*	6
	1988	2000	-3.640	6	1984	1993	-12.355*	3
$\ln U_t$	1998	---	-3.380	6	2000	----	-5.332**	6
	1989	1998	-4.553	4	1996	2000	-12.611*	1
$\ln O_t$	1995	---	-1.105	6	1974	---	-7.122*	4
	1974	1995	-3.544	3	1974	2004	-7.649*	1
Note: T_{B1} and T_{B2} are the dates of the structural breaks; k is the lag length; * and ** show significant at 1% and 5% levels respectively.								

This intends us for applying combined cointegration technique suggested by Bayer and Hanck, (2013) in examining cointegration between electricity use, economic growth, urbanization and trade. The results of Bayer-Hanck combined cointegration test are shown in Table-6. It is noted that Fisher-statistics for EG-JOH (EG-JOH-BO-BDM) tests are more than critical bounds at 5% significance level. The results show 4 (2) cointegrating vectos as we used electricity consumption, economic growth, urbanization and trade (electricity consumption and economic growth) as dependent variables. This favours us in rejecting the null hypothesis i.e. cointegration does not exists among the series. The empirical evidnce validates the existence of two cointegrating vectors between the variables. This shows the occurrence of long-run relationship between electricity use, economic growth, urbanization and trade covering the period of 1971-2012 for Algerian economy.

Table-6: The Results of Bayer and Hanck Cointegration Analysis

Estimated Models	EG-JOH	EG-JOH-BO-BDM	Lag Order	Cointegration
$E_t = f(Y_t, U_t, O_t)$	11.157**	23.893**	2	Yes
$Y_t = f(E_t, U_t, O_t)$	10.995**	66.587**	2	Yes
$U_t = f(E_t, Y_t, O_t)$	10.978**	17.187	2	No
$O_t = f(E_t, Y_t, U_t)$	11.282**	12.891	2	No
Note: ** represents significant at 5% level. AIC is followed to chose appropriate lag order.				

Although, Bayer-Hanck combined integration test gives efficient and reliable empirical results. But the main demerit of Bayer and Hanck, (2013) combined cointegration test is that this test is unable to contain information about unknown structural breaks stem in the series while determining cointegration relationship between the variables. We solve this issue by employing bounds testing approach for examining cointegration between the variables while acoomodting structural breaks stem in the series following Shahbaz et al. (2013, 2014). The bounds test provides different ARDL F-statistics at different lag orders. This shows the sensitivity of bounds testing with lag length selection. In doing so, the AIC criterion is used to chose appropriate lag order of the variables follwoing Lütkepohl, (2006). The results of bounds testing approach are detailed in column-2, Table-7. The AIC criterion is used for determining the lag order selection and maximum lag length is 2. The ARDL F-statistic is computed to confirm whether cointegration exists or not. The critical bounds generated by Narayan, (2005) have been used for making decision about the presence of cointegration. We find that the ARDL F-statistic exceeds the lower critical bound as we used electricity consumption, urbanization and trade openness as explanatory variables. This clearly confirms that the cointegration exists between electricity use, economic growth, urbanization and trade in the case of Algerian economy.

Table-7: The Results of ARDL Cointegration Test

Bounds Testing to Cointegration				**Diagnostic tests**		
Estimated Models	Optimal lag length	F-statistics	Break Year	R^2	$Adj-R^2$	D. W test
$E_t = f(Y_t, U_t, O_t)$	2, 1, 2, 2	3.489	1997	0.7706	0.5958	1.9621
$Y_t = f(E_t, U_t, O_t)$	2, 2, 2, 2	5.519**	2000	0.8173	0.6621	2.0273
$U_t = f(E_t, Y_t, O_t)$	2, 2, 0, 2	3.043	1998	0.7545	0.5871	2.2098
$O_t = f(E_t, Y_t, U_t)$	2, 2, 2, 2	2.154	1995	0.4167	0.0191	2.0554
Significant level	Critical values					
	Lower bounds $I(0)$	Upper bounds $I(1)$				
1%	5.920	7.197				
5%	4.083	5.207				
10%	3.330	4.347				
Note: ** represents significant at 5% level.						

The long run impacts of economic growth, urbanization and trade on electricity use are shown in Table-8. We find that economic growth has positive and significant impact on electricity consumption. It is noted that a 1 percent increase in economic growth leads electricity consumption by 1.13% by keeping other things constant. We found, most of existing empirical findings also indicate the similar indication, where economic growth has a positive impact on electricity use (Narayan and Smyth 2009, Jumbe 2004, Solarin and Shahbaz 2013, Chandran et al. 2010, Qdhiambo 2009, Lin and Liu 2016). We should take note that electricity consumption growth was inconsistent with economic growth in Algeria. We find that, electricity growth rate was almost 11%, while GDP growth was 3.8% in 2014). Take Algeria as an example, industrial and manufacturing production contributes to economic growth and this factor are highly related to electricity consumption which highly sensitive to economic growth. When we compared with most of the previous empirical findings related to electricity consumption-economic growth, we note that the more economic growth performed, more electricity consumption fluctuated over time.

The impact of urbanization is positive and significant at 1% level. All else is same, a 1% increase in urbanization leads electricity demand by 2.30%. This result is consistent with Chandran et al. (2010), Acaravci and Ozturk (2010), Apergis and Payne (2011), Gam and Ben Rejeb (2012), Bélaïd and Abderahmani (2013), Solarin and Shahbaz (2013), Liddle and Lung (2014), Rafinddadi and Ozturk (2016), Bento and Moutinho (2016), and Lin and Liu (2016). Hence, it is likely the urbanization process in Algeria has a positive impact on electricity use. With a sustainable economic growth in Algeria, urbanization process can be roughly divided into 2 processes. First, because urban population has been gradually increasing over years and almost 70% of population lives in urban areas. In terms of energy use, urban residents will consume more electricity and this what has been happening in Algeria. Secondly, industrial and manufacturing activities namely in urban area also increase the usage of energy, especially electricity. This is not a surprising result because substantial studies has used urbanization as an explanatory variable to seek and explain the relationship between renewable energy (electricity) and economic growth. However, in some isolated cases, we found that urbanization contributed more towards the growth of non-renewable energy sources comparatively of renewable energy consumption (Yang et al. 2015).

However, trade openness impacts electricity demand negatively and significantly. We find that a 1% increase in trade openness lowers electricity use by 0.0722% if all other things are constant. Responding on our result, trade balanced of Algeria has a stable mode in recent decades and remains depend with petroleum, coal and ammonia as the top exports. We count only few studies focusing on electricity consumption and trade activities which employed time series empirical analysis (Narayan and Smyth 2009, Srinivasan 2013, Shahbaz et al. 2014, Keho 2016, Rafindadi and Ozturk 2016, Awad and Yossof, 2016). Our finding is a bit misleading with most of previous empirical results, where we found that increase in trade lead will reduce electricity consumption for Algeria. Typically, our finding is not in line with recent studies by Rafindadi and Ozturk (2016) and, Bento and Moutinho (2016) indicate that trade openness (exports and imports) has a causal relationship with electricity consumption. Similar cases were found from empirical studies by Lin et al. (2016) for China, and Pfeiffer and Mulder (2013) for numbers of developing countries, where increases in trade will delay renewable energy consumption (electricity). The impact of dummy variable has negative and significant impact on electricity demand. This shows that implementation of economic reforms has reduced electricity demand significantly.

The results of short run model are shown in Table-8 (panel-B). We note that economic growth has positive and significant impact on electricity consumption. In the short run, a 1% increase in economic growth increases electricity demand by 0.39% by keeping other things constant. Urbanization positively and significantly impacts electricity consumption. All remainssame; a 1% increase in urbanization leads electricity consumption by 4.65% rise in electricity demand. The impact of trade on electricity consumption is negative but insignificant. The effect of dummy variable is negative but significant at 5% level. The estimate of ECM_{t-1} is negative and statistically significant at 1 percent significance level. This shows the speed of convergence in electricity demand from short run towardits long run equilibrium path. The short run variations are corrected by 29.13% every year. The value of ECM shows that the short run adjustment would require nearly 3 years and 5 months for converging to its long run equilibrium. The diagnostic tests show that error term of the short run model is normally distributed and it is free from heteroskedasticity, serial correlation, and ARCH problems. The value of Ramsey reset test shows that the functional form is well specified.

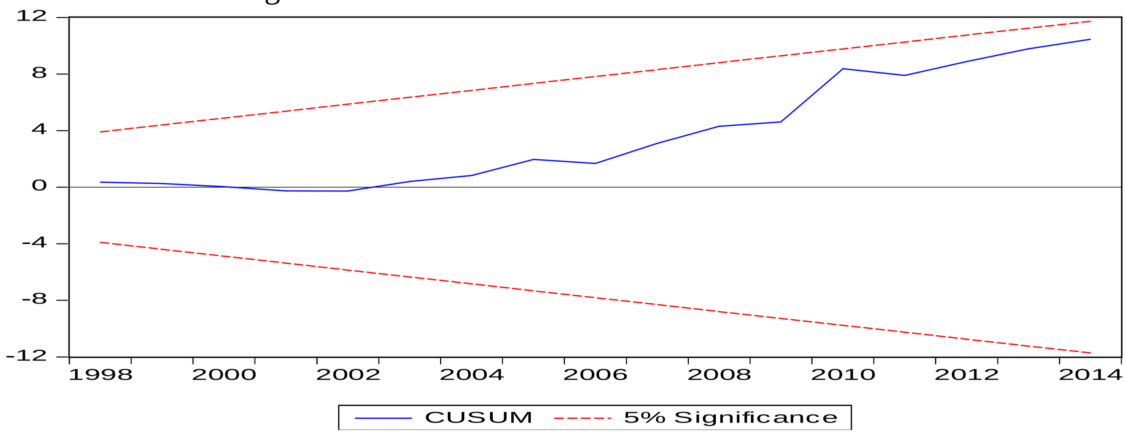
Table-8: Long and Short Run Analysis

Dependent Variable = $\ln E_t$			
Panel- A: Long Run Results			
Variables	Coefficient	Std. Error	T-statistics
Constant	-12.3218*	2.0623	-5.9748
$\ln Y_t$	1.1253*	0.2522	4.4620
$\ln U_t$	2.2993*	0.1209	19.0126
$\ln O_t$	-0.0722**	0.0284	-2.5449
D_{1997}	-0.1977***	0.1058	-1.8682
R^2	0.9464		
$Ajd-R^2$	0.9322		
Panel-B: Short Run Results			
Constant	-0.0210	0.0343	-0.6146
$\Delta \ln Y_t$	0.3873***	0.2286	1.6945
$\Delta \ln U_t$	4.6492***	2.3336	1.9922
$\Delta \ln O_t$	-0.0065	0.0074	-0.8765
D_{1997}	-0.0367**	0.0174	-2.1075
ECM_{t-1}	-0.2913*	0.0819	-3.5535
R^2	0.3070		
$Ajd-R^2$	0.2255		
D-W Test	1.9732		
F-statistic	3.7667**		
Diagnostic Test			
Test	F-statistic	Probability	
$\chi^2 SERIAL$	0.0914	0.9128	

$\chi^2 ARCH$	0.2033	0.6547	
$\chi^2 WHITE$	0.5044	0.8432	
$\chi^2 REMSAY$	0.1553	0.6959	
Note: *, ** and *** represent significance at 1%, 5% and 10%level respectively. $\chi^2 SERIAL$ is for serial correlation, $\chi^2 ARCH$ for autoregressive conditional heteroskedasticity, $\chi^2 WHITE$ for white heteroskedasticity and $\chi^2 REMSAY$ for Resay Reset test.			

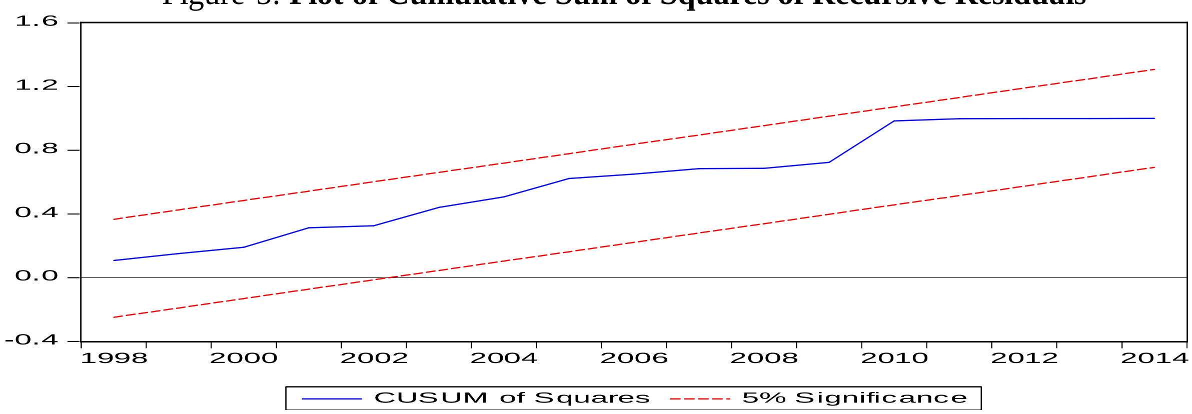
For ensuring the stability of long-and-short run estimates of our model the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) are used as proposed by Brown et al. (1975). The plot of the CUSUM in Figure-4 is found to be lying within the regions of two extreme bound lines and the statistic is significant at 5%. Similarly, the plot of the CUSUMsq (Figure-5) does lie within the regions of those two lines and the statistic is significant at 5 percent level. This validates that long-and-short runs estimates are stable.

Figure-4: **Plot of Cumulative Sum of Recursive Residuals**



The straight lines represent the critical bounds at the 5% significance level.

Figure-5: **Plot of Cumulative Sum of Squares of Recursive Residuals**



The straight lines represent the critical bounds at the 5% significance level.

For investigating the causal relationships among the variables in our electricity demand function, the study further utilizes the Variance Decomposition Analysis (VDA) and Impulse Response Analysis (IRA) is known as innovation accounting tools in the vector autoregression (VAR) model. The results of the VDA are presented in Table-9 until 15 horizon periods. It shows that the variation in electricity consumption is largely accounted by itself i.e. 51.34% and then the rest of its variations are explained due to urbanization i.e. 32.21%. The contribution of economic growth and trade is minimal. Economic growth and trade explain electricity consumption by 3.5% and 12.94% respectively. Economic growth is explained by electricity consumption minimally. On other hand, urbanization and trade contribute to economic growth by 34.58% and 32.06% respectively. A 27.24% of economic growth is explained by its own innovative shocks. This implies that all the factors play quite significant roles in explaining electricity demand. We find that urbanization is highly explained by its own shocks and electricity demand contributes to urbanization by 34.49%. The contribution of economic growth and trade openness to electricity demand is 1.61% and 12.85% respectively. Electricity use, economic growth and urbanization add in trade openness minimally. Overall, our results indicate that the feedback effect exists between urbanization and electricity consumption. Urbanization leads economic growth. Economic growth is also caused by trade openness. Trade does not cause electricity use and electricity use does not cause trade and, same is true for trade openness and urbanization. Neither economic growth causes electricity consumption nor electricity consumption causes economic growth.

Table-9: Variance Decomposition Approach

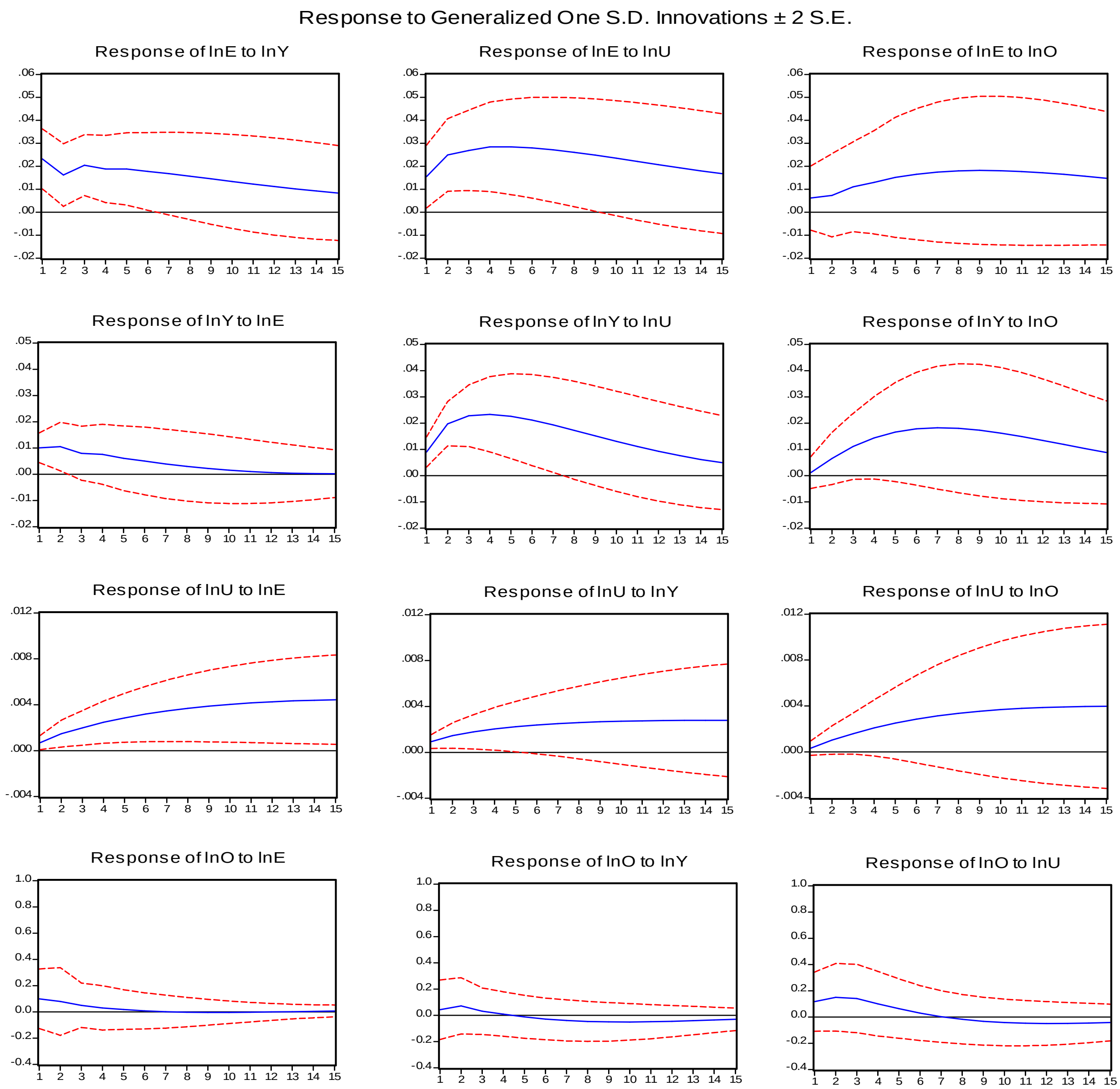
Variance Decomposition of $\ln E_t$					
Period	S.E.	$\ln E_t$	$\ln Y_t$	$\ln U_t$	$\ln O_t$
1	0.0445	100.0000	0.0000	0.0000	0.0000
2	0.0532	88.2704	0.8694	10.7311	0.1289
3	0.0635	83.3079	1.5324	14.4781	0.6814
4	0.0716	77.0359	2.2030	19.2259	1.5350
5	0.0790	72.3842	2.6953	22.2502	2.6701
6	0.0855	68.2562	3.0719	24.7326	3.9391
7	0.0913	64.8314	3.3334	26.5702	5.2649
8	0.0964	61.9171	3.5064	28.0050	6.5713
9	0.1009	59.4694	3.6080	29.1099	7.8124
10	0.1048	57.4139	3.6558	29.9732	8.9570
11	0.1083	55.6987	3.6639	30.6490	9.9883
12	0.1113	54.2744	3.6440	31.1820	10.8994
13	0.1139	53.0985	3.6056	31.6051	11.6906
14	0.1161	52.1335	3.5560	31.9434	12.3669
15	0.1180	51.3463	3.5008	32.2163	12.9365
Variance Decomposition of $\ln Y_t$					
Period	S.E.	$\ln E_t$	$\ln Y_t$	$\ln U_t$	$\ln O_t$
1	0.0192	27.1939	72.8060	0.0000	0.0000
2	0.0302	23.0804	59.7180	15.6865	1.5149
3	0.0400	17.1182	52.1754	25.6470	5.0591

4	0.0485	14.0537	46.5575	30.4054	8.9833
5	0.0558	11.7829	42.2337	33.0815	12.9018
6	0.0620	10.2095	38.8376	34.4108	16.5419
7	0.0671	9.0477	36.1188	35.0557	19.7776
8	0.0713	8.1908	33.9314	35.2994	22.5783
9	0.0747	7.5543	32.1711	35.3270	24.9474
10	0.0774	7.0844	30.7625	35.2404	26.9125
11	0.0794	6.7405	29.6466	35.1028	28.5099
12	0.0809	6.4921	28.7753	34.9515	29.7809
13	0.0821	6.3155	28.1078	34.8082	30.7683
14	0.0829	6.1919	27.6084	34.6843	31.5152
15	0.0835	6.1071	27.2456	34.5842	32.0629
Variance Decomposition of $\ln U_t$					
Period	S.E.	$\ln E_t$	$\ln Y_t$	$\ln U_t$	$\ln O_t$
1	0.0020	12.1399	11.0625	76.7975	0.0000
2	0.0038	17.9536	7.3659	73.2359	1.4444
3	0.0056	20.5655	5.8535	70.5047	3.0762
4	0.0074	23.1221	4.8519	67.3215	4.7043
5	0.0091	25.1149	4.1369	64.5735	6.1744
6	0.0107	26.7949	3.5946	62.1545	7.4558
7	0.0123	28.1919	3.1708	60.0880	8.5491
8	0.0138	29.3796	2.8316	58.3162	9.4725
9	0.0153	30.4001	2.5552	56.7966	10.2474
10	0.0167	31.2898	2.3266	55.4862	10.8973
11	0.0181	32.0742	2.1352	54.3500	11.4404
12	0.0194	32.7732	1.9732	53.3591	11.8943
13	0.0206	33.4015	1.8350	52.4898	12.2736
14	0.0218	33.9703	1.7161	51.7229	12.5906
15	0.0229	34.4881	1.6131	51.0431	12.8556
Variance Decomposition of $\ln O_t$					
Period	S.E.	$\ln E_t$	$\ln Y_t$	$\ln U_t$	$\ln O_t$
1	0.7191	1.9082	0.0258	1.8511	96.2147
2	0.8261	2.3535	0.2070	3.7131	93.7262
3	0.9097	2.2372	0.1743	5.3680	92.2203
4	0.9558	2.1233	0.1644	6.0876	91.6246
5	0.9834	2.0368	0.2213	6.3301	91.4116
6	0.9989	1.9783	0.3588	6.3429	91.3198
7	1.0076	1.9446	0.5750	6.2764	91.2039
8	1.0124	1.9267	0.8495	6.2162	91.0074
9	1.0155	1.9171	1.1568	6.1987	90.7273
10	1.0177	1.9102	1.4704	6.2311	90.3881
11	1.0198	1.9033	1.7683	6.3047	90.0235
12	1.0219	1.8957	2.0344	6.4039	89.6658
13	1.0240	1.8879	2.2597	6.5129	89.3393

14	1.0262	1.8813	2.4415	6.6184	89.0586
15	1.0282	1.8773	2.5814	6.7116	88.8296

Figure-6 indicates the empirical evidence by impulse response function (IRF). The IRF outlines the behavioral response of one variable over time, following a standard deviation shock against the standard deviation shocks stemming in other variables. We note that the response in electricity consumption is positive due to standard deviation shock occurs in economic growth and trade. Economic growth responds positively due to shocks in urbanization and trade openness but having downward trend. The response in economic growth is positively initially but depletes after 11th time horizon. The input of electricity use, economic growth and trade openness to urbanization is positive. Trade responds minimally due to standard deviation shocks stemming in electricity consumption, economic growth and urbanization.

Figure-6: Impulse Response Function



5. Concluding Remarks and Policy Recommendations

The paper re-examined the short-run and long-run relationships between electricity consumption and economic growth in the case of Algeria over the period of 1971-2012. The inclusion of urbanisation and trade openness in the study is purposely to extend the traditional closed economy hypothesis to the context of open transition economy. We carried out the ARDL bounds approach to investigate the long run relationship between the variables while dummy variable is included to capture the structural breaks estimated by Clemente-Montanes-Reyes unit root test. We find that the cointegration exists between electricity consumption, economic growth, urbanization and trade openness in the case of Algerian economy. For the sake of consistency the study employed combined cointegration test which confirmed the presence of equilibrium long-run relationship among the underlying variables. Economic growth and urbanization has a positive and significant impact on electricity consumption however trade openness has a negative effect. To conclude the direction of causality between electricity consumption, economic growth, urbanization and trade openness, we used innovation accounting approach. A neutral effect is found to run from economic growth to electricity consumption. This finding support the neutrality hypothesis, hence shocks to energy supply will have insignificant effect to economic growth in Algeria. It also implies that changes in economic growth are unlikely to have significant effect on electricity consumption. The findings have useful policy implications for decision makers, as energy conservation is a reasonable policy with no damaging consequences on economic growth for Algeria. Moreover, long-run electricity policies can be directed towards promoting the use of renewable resources (such as solar and wind) to generate electricity power which will help to reduce carbon emissions. The feedback relationship is also found between urbanization and electricity consumption. Thus, in order to sustain the urbanization development, the Algerian government should continue to invest in the sector of electricity generation by using renewable sources as this country has a high potential in thermal solar power to become an electricity energy exporter.

Indeed, we can see that the electricity generated in Algeria can be part of the nation's economic generation indicator. Where, the country is now aiming 22GW of renewable energy capacity by 2030 with 60% of domestic electricity demand and the rest will be destined for exports. In conjunction of this scenario, more demand for electricity will be supported through solar energy generation. This will be an ideal opportunity for integrating both renewable and non-renewable energy (fossil and natural gas) for domestic electricity consumption. This study clearly indicates that the largest electricity consumption is related to economic growth, urbanization and trade activities. The contribution of economic growth and urbanization has dynamic linkages with electricity demand and the Algerian government should put more attention seeking renewable energy cooperation within the region by emphasizing advanced green and clean technologies. Therefore, it would improve the country's ability of providing energy supply for economic development purposes in near future. Future research should give more attention on residential and manufacturing sector electricity consumption, real oil prices, financial development and environmental sustainability on electricity consumption so that specific policy implications can be drawn. Last but not least, electricity consumption-eocnomic growth nexus can be investigated by including variables such as energy costs or energy sales and direction with close countries in future.

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